
III. Summary: Projects of the Galveston Bay National Estuary Program

This section is a comprehensive project-by-project summary of GBNEP projects initiated since the Program began in 1989. Most project results are (or will be) published in the GBNEP publication series.

What are Galveston Bay's Problems, and Which are Most Important?

Recognizing and Ranking the Problems

The Galveston Bay Priority Problems List

Bringing the Bay's problems into focus and agreeing upon them was one of the Program's first goals. This process of reaching consensus began in the Spring of 1989, with a preliminary *Priority Problems List*, public meetings, and extensive committee discussions. After many revisions, consensus was successfully reached identifying and ranking these problems. The *Priority Problems List* was then approved by the Policy Committee in November, 1989, as a tool to guide the work of the GBNEP. Many times since then, the List has helped keep the program "on track" in the face of diverging opinions and differing values among the many involved with Galveston Bay. The *Priority Problems List* is reproduced on page 3 of this document.

Human Disturbance of Valued Bay Resources

The "Ecosystem Impact Matrix"

The identified problems in Galveston Bay were further defined by development of an "Ecosystem Impact Matrix" which highlights the relationships between valued estuarine resources and human and natural disturbances (see page 4). The Matrix facilitates agreement on which Bay resources are most valued, identifies which of these are at greatest risk, and which cannot be evaluated because of "knowledge gaps." Because the ecosystem is so complex, the Matrix helps depict relationships between man and the Bay not possible to characterize in the Priority Problems List.

Building a Common Understanding of the Bay

Ecosystem Conceptual Model

Because Galveston Bay is so complex (as are all ecosystems), everyone has a different idea of how it works. With the human influences on the Bay added to all the natural complexity, different people involved with the Bay are left with scant common understanding as a basis for problem-solving. This project results in a

model of the Bay consisting of a series of diagrams and a narrative report which has three levels of complexity: a simple non-technical tier understandable to the public; a simple but technical tier useful to resource managers, decision-makers and informed bay users; and a detailed scientific tier incorporating a full range of structural and functional complexity.

A key aspect of the project is a consensus-building approach to building the model--that is, it will be built upon the joint understanding of many experts. The core of the model will be the key Bay habitats: open Bay water; open Bay bottom; emergent marsh wetlands; algal flats; seagrass meadows; and oyster reefs. The ecological and human-caused processes related to these will be incorporated to yield an "ecological manual" that will simplify the real ecosystem while preserving its essential features.

By contributing to a common understanding of the Bay, the model will: improve communication among decision-makers, advisors, and the public; help assure regulatory decisions are not at cross-purposes; aid in matching the scale of solutions to the scale of the problems; and help predict the secondary ecological effects of actions taken. Robert McFarlane (McFarlane and Associates) is the principal investigator for this GBNEP project.

Scientific Characterization of the Problems and their Causes

Threats to the Bay's Productivity **Wetland Habitat Survey**

Approximately 95% of all commercially important species in the Gulf of Mexico depend upon estuaries and their highly productive wetlands for life support. Wetlands are therefore widely recognized among the most valued resources of Galveston Bay and are known to be decreasing in the estuary as a result of human activity. This three-year study, begun in Spring of 1990, involves mapping of shoreline and submerged aquatic vegetation (seagrass) habitats based on aerial photo interpretation. Field studies of plant communities are being utilized to verify the findings. Aerial photo sets from 1956, 1979, and 1989 will determine the historical trends for losses of specific kinds of wetlands over this time period.

Computer mapping of project results for a geographic information system (GIS) will allow elaborate analyses of these historical trends for specific habitat types. Project publications will help draft habitat conservation initiatives in the CCMP. Publications will include a wetlands bibliography for Galveston Bay, a wetland plant community synopsis, detailed wetland maps, and a report characterizing habitat trends and probable causes for wetland losses. Principal investigators are E. G. Wermund, Bureau of Economic Geology, and Lawrence R. Handley, National Wetlands Research Center, U.S. Fish and Wildlife Service.

Known Sources of Pollution

Point Source Loading Studies

Some sixty percent of all wastewater discharged in Texas flows to Galveston Bay, making the Bay, in effect, the final step in most Texas wastewater treatment. These legally permitted wastewater discharges (and the resulting pollutants in river water entering the estuary) are the focus of this study. Concerns included selected nutrients, some toxicants, and traditional water quality parameters.

The approach taken for this study requires compilation and analysis of already-existing data, primarily from permit and surface water monitoring programs--for example those of the Texas Water Commission. Currently, discharge permits are granted based on the impacts to receiving waters only in the localized area ("segment") where the discharge is located. This study will contribute to a much broader understanding of the loadings of pollutants to the entire Bay system. The CCMP will be drafted from this cumulative ecosystem perspective, including the effects of all point and nonpoint sources of pollution throughout the entire Bay. Trends determined will also help identify causes for water quality changes.

Results of this projects will be published in a GBNEP publication by principal investigators Neal E. Armstrong (Department of Civil Engineering, University of Texas at Austin) and George H. Ward, (Center for Research in Water Resources, University of Texas at Austin).

Searching Out Unauthorized Polluters

Shoreline Survey for Point Source Discharges

Many citizens and environmental professionals have long suspected that substantial illegal sources of wastewater exist along the shorelines of Galveston Bay. This survey of 159 selected shoreline miles justified this concern, with some qualifications. Discharges were identified and documented using aircraft and shallow draft boat surveys.

In the study area, the number of illegal discharges discovered exceeded the 120 legally permitted discharges in the same area. Most were of apparently minor importance to the Bay. Discharges varied from flowing pipelines to apparently inactive sources. One management need identified by the study was the need for signs identifying permitted wastewater outfalls; such a requirement would make pollution survey and enforcement work much more feasible.

All unpermitted discharges identified in the study were reported to the appropriate regulatory agencies for further investigation and enforcement. In addition to substantiating a suspected impact on the estuary, the study also helped document the feasibility and need for extending the survey to some or all of the entire bay/tributary shoreline (2,491 miles). This work is published as report GBNEP-12 (August, 1991) by Roger R. Fay, Stephen Sweet, and R. J. Wilson of the Geochemical and Environmental Research Group, Texas A&M University.

Wastes that Wash off the Land

Nonpoint Source Loading Study

Nonpoint source pollution is massive, diffuse, and as yet largely unregulated. For example, studies indicate that storm water washing off a single metropolitan area in a year can contribute oil and grease to nearby waterways amounting to about half the volume of the Exxon Valdez spill. This study documented substantial nonpoint pollution of Galveston Bay, and will contribute to CCMP initiatives to address the problem.

The GBNEP approached non-point source pollution by mapping watershed hydrology and land use using a Geographic Information System (GIS), allowing estimation of pollutant loading to Galveston Bay for several selected contaminants. Subwatersheds were then ranked for their pollutant contributions to the Bay, to allow geographic targeting of the problem by managers. The emphasis was on urban lands in the immediate watershed draining to bayous or the Bay--a principal source of the problem. Of secondary concern were drainage basins of the Trinity River, San Jacinto River and other tributaries with less immediate effect on the Bay, but which contribute substantial nutrient pollutants.

Findings indicated up to a billion pounds of sediments, oil and grease equivalent to a 130,000 barrel spill, and massive amounts of the nutrients nitrogen and phosphorus enter the Bay annually from diffuse sources. GBNEP Task Forces will utilize these results, (and results from point source and shoreline survey studies) to develop water quality improvements for Galveston Bay. Findings will be summarized in a report by Charles J. Newell, Hanadi S. Rifai, and Philip B. Bedient.

Contaminants Already in the Bay

Ambient Water/Sediment Quality Study

Many of the pollutants introduced into Galveston Bay tend to stay there because the pollutants attach to sediment particles and become incorporated in the bay bottom. Contaminants may also be dissolved, or can be concentrated in living plants and animals. Goals of this study are to characterize the existing water and sediment quality in the Galveston Bay complex, and to identify trends based on this data. Work will first screen the historical data for its usefulness for this purpose; then analyses will be conducted to determine historical and geographic trends in water and sediment quality related to human activity.

Results of this project will be used to make comparisons between actual contaminant levels and existing regulatory water standards. Future management of the Bay can then concentrate on "hotspots," where current regulation falls short, and where information gaps exist. Future monitoring of water and sediment quality will also utilize this Bay-wide analysis of past monitoring data. A report will be authored by George H. Ward (Center for Research in Water Resources, University of Texas at Austin) and Neal E. Armstrong (Department of Civil Engineering, University of Texas at Austin).

Concern for What Lives in the Bay

Living Resources Trend Study

Major habitat losses and a 2,000 percent increase in the total harvest of animals during the last 100 years (including offshore harvest of shrimp and menhaden) raise serious concerns for the living resources of Galveston Bay. Living plants and animals provide both a sustainable economic benefit to Texas and serve as indicators of the ecological health of the estuary. This study compiles historical data and information to determine trends for species which are commercially important or are critical in the food web or as indicators of environmental quality. Included are shrimp, speckled trout, red drum, flounder, and blue crab. Secondary emphasis is on forage fish species, plankton, birds, and benthic (bottom-dwelling) invertebrates. (Seagrasses, salt marsh species, and oysters are considered in other specific projects).

Project results indicate no wholesale decline in species populations--in fact the Bay is very much alive. However, apparent long-term declines indicated for striped bass and diamond back terrapins, and recent declines in white shrimp, blue crab, mottled ducks, northern pintail, blue-winged teal, and all colonial water birds (except olivaceous cormorants) provide ample reason for concern.

GBNEP publications resulting from this project will include a major status and trends report for the species selected for the study and a second report detailing probable causes for declines and other findings. The work is being accomplished by a project team coordinated by Albert W. Green, Resource Protection Division of the Texas Parks and Wildlife Department.

A Keystone Species

Bay-Wide Oyster Survey

Of the thousands of species which depend upon Galveston Bay, oysters perhaps best typify our concerns for human influences on the Estuary. Oysters are a commercial species; they are sensitive indicators for the critical mixing of river water and salt water from the Gulf of Mexico; they are a good gauge of contamination by sewage and toxic chemicals; they are at the heart of dredging project controversies; and they create shell reef habitat (the only significant hard substrate habitat in the estuary). Perhaps most important, oysters can't move: they can't escape human-caused, or natural changes in the estuary.

This project makes use of state-of-the-art navigation and sonar technology to survey and map oyster reefs throughout the Bay system. Results are compiled in a Geographic Information System (GIS) to provide a basis for assessing human impact to this critical species. During the survey, sampling at selected locations will establish the health of individual oysters and the reef communities, including incidence of disease, parasitism, and predation. Reef maps, and findings from existing data and literature compiled during this three year project will appear in a report by Eric N. Powell (Department of Oceanography, Texas A&M University).

Can I Eat the Seafood?

Survey of Toxicants in Aquatic Organisms

No subject concerns the public more than cases in which fish and shellfish are dangerously contaminated with toxicants. For example, dioxin contamination recently resulted in a fishery closure of upper Galveston Bay. The lack of a systematic seafood inspection program compounds this problem. This project was created to determine if toxic contamination in seafood organisms is an ecosystem-wide problem in Galveston Bay.

The approach involved collection of five commercial/recreational fish and shellfish species from each of four widely separated locations in Galveston Bay, for analyses for 126 specific contaminants in edible tissue. State-of-the-art laboratory analytical procedures were utilized to determine contaminant concentrations, for use in a specialized procedure called "risk analysis".

Results of the project show generally higher tissue contamination levels in the upper portion of Galveston Bay near the Houston Ship Channel. However, a risk analysis revealed that none of the average concentrations of trace metals or trace organic contaminants pose a risk to human health. While these results highlight a relatively "clean" part of the ecosystem, they suggest that contamination, where present, is likely to be a "hot spot" phenomenon rather than a systematic problem. GBNEP will publish a project report by James M. Brooks (Geochemical and Environmental Research Group, Texas A&M University).

Does the Bay Pose Human Health Risks?

Public Health Synopsis

More than half of Galveston Bay is closed (either provisionally or permanently) to the taking of shellfish, due to the risk from human disease-causing bacteria polluting the Bay. Some portions of the Bay have such high levels of bacteria that even water contact activities pose a risk. Other areas have been closed to fishing activity due to toxic chemical contamination, for example by dioxin. This project will help determine the extent and sources of these public health problems.

One objective of the study is to compile an historical synopsis of shellfish bed closures ordered by the Texas Department of Health, including locations and reasons for the closures. A second concern is to quantify the sources of bacterial contamination by documenting large-scale processes from: existing resource agency data; calculation of the contamination resulting from a typical one-inch rainfall and the identification of indicator bacteria associated with runoff; and hydrographic conditions in different portions of the Bay. Regulatory water quality standards for contact and non-contact recreation exist for the waters of the Bay; this study will also determine the historical trends in violation of these standards.

Results of the project will help determine future management of the aspects of Galveston Bay which affect public health. Results will be published in a report authored by principal investigator Paul Jensen of Espey, Huston, and Associates.

Defining Toxic Hotspots in the Bay

Survey of Toxicants in Sediments and Bottom Creatures

Almost a million pounds per year of toxic substances are discharged to the Houston Ship Channel alone. Oysters transplanted to the Houston Ship Channel from "clean" portions of the Bay increase by 15 times their tissue concentration of highly carcinogenic PAHs (Polycyclic Aromatic Hydrocarbons) and by 28 times their tissue concentration of PCBs (Polychlorinated Biphenyls). The Houston Ship Channel also periodically exceeds EPA and State toxicity criteria, and samples of water from throughout the Channel produce toxic responses in live test animals. Because most toxic materials tend to become associated with sediments, this project concentrates on the toxicity of sediments and related effects on bottom communities and test animals in the laboratory. The overall aim is to determine the extent of toxic "hotspots" in Galveston Bay.

Based on existing data, about 15 sites were chosen corresponding to suspected problem areas and comparison with "clean" locations. At each location, sediment analysis for a range of toxic contaminants is conducted; the number and kinds of animals occurring in the natural bottom-dwelling community are determined (a good supplementary test for toxicity problems); and toxicity tests on living test animals are conducted. These three lines of evidence (termed a "triad" approach) characterize toxic contamination. Results of the project, directed by R. Scott Carr of the U. S. Fish and Wildlife Service, will be available in a GBNEP Publication.

Fishery Losses Incidental to Bay Uses

By-Catch Studies

Shrimpers working off the Texas coast take an estimated 600 million pounds of non-targeted fish each year, and serious concerns have been raised for the welfare of some non-target species. In Galveston Bay, even rough estimates of by-catch are lacking, and no one knows if non-target Bay species are suffering declines incidental to human activity in the Estuary. Several particular activities are of concern; GBNEP by-catch studies will address three of these concerns.

First, the magnitude of by-catch resulting from shrimp trawling in Galveston Bay will be determined. Trawl studies scaled to the level, timing and location of commercial trawling in the Bay will determine species, numbers, and growth stages of by-catch. Results will highlight implications for key fishery stocks in the Bay. The project is directed by James Nance, National Marine Fisheries Service. Second, by-catch from recreational fishermen (that is, fish of unintended species caught by sport fishing) pose an unknown influence on the living resources of the Bay. This aspect of by-catch will be investigated by Gary E. Saul, FTN Associates, Ltd. Third, incidental mortality will be estimated for activities other than fishing. These activities include impingement (the mortality resulting from water intake structures like industrial cooling water intakes); dredge operations; seismic exploration; pipeline activity; and oil and gas operations. Principal Investigator for this portion of the by-catch investigation is Victor Palma of Jones and Neuse, Inc.

Human Alteration of Circulation, Salinity, and Habitat **Dredge/Fill Impacts Study**

The greatest human physical alterations to Galveston Bay result from construction of navigation channels and other dredge and fill operations, making dredging projects among the most controversial human activities associated with the estuary. These projects contribute major economic benefits to the state from shipping, but also redirect circulation and alter the salinity of the Bay in ways that can affect long-term productivity and ecological integrity. This project compiles historical Army Corps of Engineers data from the mid-1940s to present to provide an overview of dredge/fill activity and effects on the Bay.

Specific information to be addressed for permitted projects includes: quantity of material dredged; disposal locations by habitat type and resulting alterations; and extent of salinity and circulation alterations. Information to be compiled concerning the permit process itself includes: number of permits issued and number involving habitat modification; estimates of resulting habitat area lost or gained; number and area of private channels constructed; and justifications for the projects permitted. GBNEP will publish a report prepared by principal investigator George Ward, Center for Research in Water Resources, University of Texas at Austin.

Scientists Contribute to Bay Management **Characterization Workshop**

In February, 1991, scientists gathered to share research findings and information concerning Galveston Bay. Their contributions helped successfully accomplish four broad goals: first, to identify scientific work on Galveston Bay being conducted by institutions other than the GBNEP; second, to promote peer interaction among the principal investigators involved in this research; third, to improve our understanding of estuarine problems in need of management solutions; and finally, to encourage project coordination in an ecosystem context. The workshop drew better-than-anticipated participation.

Several important themes were recognized that affect management of the Bay. One is a realization of the abundance of good information on the Bay (more than anyone thought existed). Another is the fragmented nature of this information and the lack of cohesiveness of the ongoing work, particularly for resource agencies charged with managing the estuary. Finally, a significant loss of historical data suggests a need for an ongoing, organized system to maintain Galveston Bay data and information.

Many other findings were presented for some twenty Bay topics. A published proceedings, edited by Frank Shipley and Russell Kiesling of the GBNEP, contains 56 scientific contributions (Publication GBNEP-6). This publication will contribute to future similar scientific meetings and the publication of the *Environmental Characterization Report* for Galveston Bay, a summary of all scientific findings related to the recognized problems in the Bay.

Managing the Flood of Data and Information

Bringing Order to Chaos

A Data and Information Strategy

Available resources for improving Bay management include results of the projects listed here, numerous historical projects, and many old data sets and publications. Without a strategy to handle and utilize these resources, they create a nightmare for both managers and citizens seeking specific information. Based on a workshop in July, 1989, a user survey, outside speakers, and committee and subcommittee deliberations, a Data and Information Management Strategy was adopted in January 1990.

Components of the strategy include: a Galveston Bay Data Base Inventory consisting of an electronic searchable index of descriptions of all data sets pertaining to the Bay; an electronic, searchable Galveston Bay Bibliography of published and unpublished reports concerning the Bay; a Galveston Bay Information Center for the permanent housing of reports, maps, photos, videos and other resources; and COMPAS, the National Oceanic and Atmospheric Administration's Coastal Ocean Management, Planning, and Assessment System. In addition to these projects (detailed individually below), coordination is being sought via a Memorandum of Understanding with the Texas Natural Resource Information System and by agreement with EPA's Ocean Data Evaluation System for permanent archiving of bay data.

Assessing the Historical Data Resource

Data Base Inventory

Effective estuary management requires review of historical data in order to scientifically document trends and to chart a future course to solve problems. The required data is scattered throughout local, state, and federal agencies in situations ranging from dusty files to elaborate computer data bases (when it is saved at all). The first step in integrating all this information for the benefit of the Bay is to identify the data and determine what portion is available.

For this project, a survey of local, state, and federal agencies and other organizations was conducted for data sets related to the Galveston Bay Priority Problems List. Next came design and compilation of an electronic, searchable, microcomputer-based data set index. The goal of this index was to enable anyone with a specific data requirement to determine where (and whether) the historical data exist, and how to access them.

Results revealed the data resource to consist of a great many small and obscure data sets and a few large ones. However, gaining access to the data was problematic: the response by agencies in providing information was generally poor, and management of older data prior to 1980 could only be described as a shambles. As a result, most of this older data appears irrevocably lost, and the factors which led to their loss are still operating today. These factors include: low

priority assigned to archiving and preservation of older data; mission-specific agency operation and the perception of old data as "obsolete;" personnel turnover with poor documentation; agency instability (i.e., government reorganization); natural calamities like fires and floods, combined with poor housing; changes in data management technology (creating such problems as obsolete and unreadable files); and a proprietary attitude toward data by those contacted.

In spite of problems with the historical data, the Data Base Inventory has become a valuable tool for current work in developing a management plan, and many recommendations have been developed to improve data management in the future. The Data Base Inventory is a DBASE system compiled by George Ward, Center for Research in Water Resources, University of Texas at Austin.

A Bay Community Resource

The Galveston Bay Information Center

In order to develop an effective management plan, the Galveston Bay National Estuary Program required that existing information concerning the estuary be assembled and accessible. Because this information has previously been so scattered, other organizations and individuals with an interest in the Bay also favor a central location for key information resources. These needs led to establishment of the Galveston Bay Information Center at the Jack K. Williams Library on the Galveston Texas A&M Campus.

The Galveston Bay Information Center includes a special collection of published and unpublished agency reports, journal articles, maps, films, videos, slide programs, and aerial photos. All GBNEP publications will be available, as well as several powerful information tools. A project called COMPAS (Coastal Ocean Management, Planning, and Assessment System) will provide a MacIntosh-based interactive information system pertaining to particular Bay resources. The electronic, searchable Galveston Bay Bibliography and Data Base Inventory will be available at the Information Center.

The Information Center is intended to become a permanent resource managed as an activity of the Texas Institute of Oceanography at the Texas A&M Galveston Campus. This GBNEP project is currently directed by William Evans, of the Texas Institute of Oceanography, with library help from Natalie Wiest, at the Jack K. Williams Library.

A key to printed resources

Galveston Bay Bibliography

No one knows for sure how many articles, reports, and other printed resources have been written about Galveston Bay. Many of these (for example, government agency reports) were never formally published or widely distributed, but contain information vital to improving management of the Bay. This project has identified more than four thousand citations and assembled them in a user-friendly bibliography designed to facilitate both research and management

activities related to Galveston Bay.

The *Galveston Bay Bibliography* will exist in two forms. First, a document of some 1,500 pages will be published by the GBNEP listing all Bay-related works, with suitable indices to support location of material on key topics. Second, an electronic, searchable version of the Bibliography will enable users to electronically search by title, author, subjects, or key words. This user-friendly computer system will represent an extremely powerful tool for resource managers, scientists, students, and the public seeking information on particular topics. The system will be accessible by telephone link with user personal computers.

The *Galveston Bay Bibliography* was designed from the beginning to utilized topics of particular concern in managing the estuary, and so will contribute to the drafting and implementation of the CCMP. The *Galveston Bay Bibliography* will become a permanent resource of the Galveston Bay Information Center, managed by Natalie Wiest at the Jack K. Williams Library.

Two Critical Coastal Preserves: Christmas Bay and Armand Bayou

A Mandate for Conservation

Nomination for Preserve Status

Christmas Bay and Armand Bayou are two critical, irreplaceable components of Galveston Bay (see the Fall, 1989 *BayLine*). Preservation of these two areas was identified as a high early priority of the GBNEP. Special funding was sought and received from the EPA for actions to designate each area as a Texas Coastal Preserve, under a new and innovative program jointly administered by the Texas General Land Office and the Texas Parks and Wildlife Department. This project took the first step toward this goal: compiling critical information for nomination of these areas as Coastal Preserves by the Texas School Land Board and Texas Parks and Wildlife Commission.

Based on substantial background research, a slide presentation and report were created emphasizing: protection of fragile biological communities including important bird rookeries; protection of unique coastal features; recognition of preservation and enhancement opportunities; and the active involvement of all concerned and knowledgeable persons and organizations. Based on this work, supervised by E. G. Wermund of the Bureau of Economic Geology, the two sites were successfully designated as Texas Coastal Preserves in February, 1990 at a ceremony attended by Senator Lloyd Bentsen.

Coastal Preserve Boundary Survey

Tide Gauge Installation

Coastal Preserve status for Christmas Bay and Armand Bayou triggered leasing of state-owned lands by the School Land Board to the Texas Parks and Wildlife Department for preserve management. Establishment of the preserves under this lease required boundary surveys to determine the extent of state-owned lands, which extend to mean high tide. The tide gauges therefore were needed for boundary determination, and also contribute critical management information concerning freshwater inflow, subsidence and erosion control. This project occurred in two phases:

Phase I: Site Reconnaissance and Tide Gauge Purchase. Installation sites were surveyed, and two fully automated water level measurement systems were purchased. These gauges were acquired to become part of a coast-wide network of instruments coordinated by the Blucher Institute at Corpus Christi State University in Corpus Christi.

Phase II: Installation, Maintenance and Operation. Gauges were installed and activated. Data generated by the gauges are part of a telemetry system of the Blucher Institute, which is coordinated with tide data systems of the General Land Office, Texas Water Development Board, and National Oceanic and Atmospheric Administration. Data are being compiled according to a detailed Quality Assurance Project Plan. This project was under the direction of Ms. Lanell Aston, Texas General Land Office.

Identifying Management Needs

Environmental Inventories

In order to draft a management plan for each new Coastal Preserve, critical environmental concerns must be defined. The Environmental Inventories in Christmas Bay and Armand Bayou compiled existing information on such concerns as endangered species, permitted point sources of wastewater discharge, dredging activities, agricultural practices in the drainage basins, and monitoring data concerning water quality and living resources.

Christmas Bay is an exceptional finfish and shellfish nursery area and harbors eight endangered or threatened species. Seven waterbird nesting colonies surround this shallow, relatively pristine Bay. The greatest concern for Christmas Bay is habitat loss. Fringing marsh wetlands have declined 8.4% between 1956 and 1979 (less decline than the rest of the Bay). Three of four submerged seagrass species found in Christmas Bay are nowhere else in the Galveston Bay system, and even though this Bay is a last refuge for sea grasses in Galveston Bay, the seagrass meadows in this system have declined 36 percent from 1956 to 1987. Preserving the seagrasses--composing the most valuable and productive habitat of the Bay--is recommended as a high priority.

Armand Bayou is a bottomland hardwood bayou on the western shore of the Bay with a relatively undeveloped watershed (considering its urban setting). The Bayou has been drastically altered by land subsidence of up to nine feet, due to groundwater and petroleum withdrawal. As a result, all 275 acres of wetlands present in 1956 have been lost, with minimal natural establishment of new wetlands. Water quality is a critical concern, with both point and non-point sources of wastewater increasing 35 percent over the last decade. Concerns include effects of development of the forested watershed and wastewater discharges that exceed the assimilative capacity of the Bayou.

Findings of these two environmental inventories were published in the GBNEP publication series (GBNEP-7 and GBNEP-8). Dr. Robert McFarlane is the author of these reports, resulting from a project grant to the Galveston Bay Foundation.

A Framework for Management

Regulatory Surveys

Just as environmental conditions in the Preserves require attention for successful management, so do regulatory authorities and activities. The Regulatory Surveys describe existing limits of jurisdiction for numerous agencies, focusing on regulatory gaps and overlaps, and on potential avenues of interagency coordination. The project concentrated on four topics: point sources of pollution, nonpoint sources of pollution, natural and living resources, and public health.

A complex regulatory framework was described for Christmas Bay, composed of nine federal and 13 state agencies, as well as five local governments. Twenty-nine activities were recognized as potentially of direct concern for management. As a result of the fragmented governmental jurisdictions, many gaps were recognized

in the current governance of this portion of Galveston Bay.

The governance of Armand Bayou is equally complex, with eight federal and 12 state agencies, five local governments, and two special districts. For Armand Bayou, 32 activities of special concern were inventoried. As for Christmas Bay, many of these activities created regulatory gaps, and raised issues of governmental coordination to be addressed in the preserve management plans.

These regulatory surveys have significance beyond improving the management of the two Coastal Preserves--they also serve as a microcosm and testing ground for similar concerns at the bay-wide level. The process of drafting management plans based on this project will therefore contribute to the Bay-wide CCMP. Project results are published in two reports (GBNEP-9 and GBNEP-10) prepared under the direction of Carl Masterson, of the Houston-Galveston Area Council.

Groundwork for Problem Solving **Regulatory Evaluations**

The comprehensive summaries of regulatory activities from the Regulatory Surveys (above) led to this next step toward integrated management of Coastal Preserves. This project determined how well the identified jurisdictions address the priority problems of the Bay, developed criteria to adequately evaluate current management, and, most importantly, developed recommendations for enhanced regulatory efforts under the management plans to be drafted. The approach taken was a series of confidential interviews of agency staff, addressing adequacy of current programs and identification of internal and interagency barriers to regulatory effectiveness.

For Christmas Bay, findings and recommendations resulted for seven concerns: point source discharges; wetlands protection; habitat protection; recreational cabins; agricultural runoff; landfill siting and inspection; and on-site sewage disposal. Similar findings resulted for Armand Bayou concerns: point source discharges; storm water runoff; wetlands protection; habitat protection; and illicit waste disposal. The recommendations are summarized in two reports to be published by the GBNEP, prepared by the project investigators Carl Masterson and Gary Mitchell of the Houston-Galveston Area Council and Duane Windsor, Rice University.

Agreeing on Critical Actions **Drafting the Coastal Preserves Management Plans**

Management of Christmas Bay and Armand Bayou should preserve and enhance water quality, habitat, and living resources. The Plans are based on the Environmental Inventory and Regulatory Survey and Evaluation projects (above), in addition to efforts under this project. The effort is also seen as a pilot-scale opportunity to develop cooperation and consensus among the agencies and user groups which must ultimately implement a similar but much larger plan for the entire estuary, the CCMP.

The Texas Parks and Wildlife Department, as the agency with statutory responsibility for Coastal Preserve Management, undertook the project of drafting these Management Plans. Advisory groups were convened for a series of actions to be undertaken for each Coastal Preserve. These groups sought consensus on the issues, followed by draft Management Plans being submitted for review by the GBNEP. A key feature of this approach is utilizing the GBNEP to solve problems that extend beyond the jurisdiction of the TPWD, through coordination with member agencies and user groups. Management Plans for each Preserve will be published by the GBNEP, for use by TPWD managers of these Preserves. Project work on behalf of the Texas Parks and Wildlife Department was coordinated by Larry McKinney.

Beyond Recommendations

Implementing Management

Implementation of the Management Plans will address problems related to water quality, site-specific needs, and problems related to habitat and living resources. The approach will focus on resource use, including point and non-point wastewater discharges, fisheries, petroleum, and recreation.

Involving the Public. The high degree of public interest in these two areas has already been encouraged by public meetings concurrent with designation of the Preserves. This effort will be continued to receive comments on the draft Management Plans.

Balancing Act: a Coastal Preserves Video. A video production is one way of stimulating public involvement concerning these Coastal Preserves. This video focused on the things that make Christmas Bay and Armand Bayou worth preserving. Topics include the seagrasses and prime nursery habitat of Christmas Bay and the uniqueness and educational values of Armand Bayou.

Early Actions Toward a Healthy Bay

Planting New Wetlands Around the Bay

Shoreline Erosion and Estuary Enhancement

Shoreline erosion is among the serious problems affecting Galveston Bay. Traditional erosion control methods such as bulkheads, groins, revetments and riprap, are expensive to construct and maintain, and are ecologically intrusive. This project was designed to create vegetated marshes as an affordable and environmentally superior alternative to costly shoreline stabilization structures. As a bonus, the created marshes contribute to the productivity and overall health of the estuary.

For this project, sprigs of *Spartina alterniflora* (a native marsh cordgrass) are transplanted along eroding shorelines in Galveston Bay to help stabilize shorelines and restore fringing wetland habitat. Specific objectives are to: 1) demonstrate to local landowners, organizations, and state and Federal agencies that the technique is feasible; 2) develop erosion control standards and specifications for Gulf Coast marsh areas for establishment of vegetative erosion control methods; and 3) demonstrate vegetative shoreline erosion control measures under different shoreline and environmental conditions.

The project is being conducted under a contract to the U.S. Soil Conservation Service, Eddie Seidensticker and Bob Nailon, Principal Investigators.

Reducing Toxic Contaminants in the Ship Channel

Pollution Prevention Planning

Galveston Bay is the final destination for wastewater from some seven million people, nearly half the petrochemical industry in the United States, and nearly a third of the refining. The Houston Ship Channel alone has some 550 permitted discharges equaling 13.4 percent of the State total. This large number of discharges in a confined area creates a tremendous potential for toxic substance contamination of the HSC in particular, and of Galveston Bay in general.

This project will focus on decreasing the amount of pollution entering the Houston Ship Channel by educating and working closely with some of the biggest industrial dischargers. The approach will include specific use of industrial waste audits, waste recovery methodologies, and waste exchange programs. The Texas Water Commission will carry out specific training of industry employees to reduce pollution by planning and development of waste recovery before the wastes get to the Bay. One goal is participation in waste exchange programs for hazardous waste generators and toxic material users who discharge directly into Galveston Bay. The industries will be selected based on an assessment of the risks facing Galveston Bay, including identification of the specific industrial processes creating the risks.

The Texas Water Commission will carry out this GBNEP project, coordinated by Priscilla Seymore, on the Pollution Prevention and Conservation staff.

Management Planning: Steps Toward a Comprehensive Plan for the Bay

Defining the Jurisdictions Involved with Galveston Bay **Bay-Wide Management Survey**

Decades ago, the natural resilience of Galveston Bay allowed many contrasting uses of the estuary with only limited damages to resources of the ecosystem. A "piece-meal" approach to management of the Bay seemed sufficient to prevent major damages. The various governmental agencies proceeded in diverse directions with incomplete coordination at the ecosystem level. But as the population around the Bay boomed, serious degradation resulted, and the fragmented management has failed to conserve the vital Bay resources.

This project took the first Bay-wide step to coordinate and improve the various management activities. Work identified existing regulatory and management activities occurring within the estuary, in order to make a careful assessment of each agency's effectiveness (see "Bay-Wide Management Evaluation," below). Findings produced a staggering array of some six hundred entities with authorities affecting the Bay. The abundance of local utility districts, river and water quality authorities, and agencies, combined with the fragmented statutes and regulations governing their activity is a challenge unique to Texas. Project findings compiled by Susan Hadden, University of Texas L.B.J. School of Public Affairs, will be available in a GBNEP publication.

How Does Current Management Fall Short? **Bay-Wide Management Evaluation**

Galveston Bay's problems include water pollution, habitat losses, and public health concerns--all issues identified in the *Galveston Bay Priority Problems List*. But not all problems are environmental--some relate to the way that existing agencies collectively address (or fail to address) these problems. Regulatory problems are not necessarily anyone's fault; the separate mandates of the various agencies (described in the Bay-Wide Management Survey, above) were not created to solve problems in an entire watershed or ecosystem. The level of coordination required is simply not built into the traditional system.

The purpose of this project is to produce a written analysis entitled *Framework for Action* which, combined with the scientific and technical characterization findings, will serve as the foundation for drafting improvements to regulatory and management activities by agencies. In accomplishing this purpose, this project will provide a substantial impetus for the CCMP.

Objectives of the project include initial identification of standards by which to evaluate management effectiveness, followed by a program-by-program review of both technical and policy elements of Bay management. Of particular interest are the root causes of gaps and overlaps identified in current regulatory activity. Are the Priority Problems agreed upon by the Bay user community being adequately

addressed by the current regulatory structure in Texas? The Framework for Action, to be authored by Susan Hadden of the University of Texas L.B.J. School of Public Affairs, will address this question. The findings of this work will be reviewed by the GBNEP Management Conference during the drafting of the CCMP.

Demarking the Bay for Management **Segmentation of Galveston Bay**

The diverse geography of Galveston Bay (and the variety of human influences) means different problems occur in different areas. Managing the Bay as an ecosystem doesn't mean treating the entire Bay alike: the problems must be carefully targeted. Segmentation (subdivision) of the estuary into smaller geographic units helps better define the Bay's problems and benefits specific management activities under the CCMP. Segmentation also helps establish the right number of routine Bay monitoring stations in the most effective locations. As a result, monitoring can give us an accurate description of the geographic variation in conditions within the estuary, as well as the overall "big picture" of estuarine health.

Segmentation of Galveston Bay was based on a variety of natural conditions, including the shape and current patterns of the Bay, its biology, and its salt and fresh water mixing processes. For practical reasons, past boundaries drawn by various agencies for management were also taken into account. The result was a map and a rationale to aid in the creation of effective monitoring or management units in the Bay. For example, one segment might include critical oyster reefs, another a navigation channel, and another a high concentration of industrial discharges. Using the findings, management can be improved by making site-specific actions under the CCMP. Project results will be available in a report prepared by Jones and Neuse, Inc., project contractor to the GBNEP.

Chronicle of the Resource **The History of Natural Resource Utilization**

The scientific projects of the GBNEP compile data to define problems to be addressed by the CCMP. However, these data only reach back a few decades. Data do not tell us much about conditions in the Bay's "pristine" state, and the data fall far short of describing the history of human interaction with the Bay--even in recent times. Therefore, this project was conceived to expand the consideration of estuary trends from the modern era of environmental management to a broader consideration of the estuary in human history--the resources it maintained and how they were used.

The project is based on old accounts in journals, fishery reports, and other documents, photos, and illustrations. Numerous interviews were conducted by trained volunteers with living elderly residents, and with representatives of historical societies and museums. Results summarize the archeology of the Bay, its early settlement by non-natives, and its previously abundant resources. What of the striped bass, tarpon, snook, ospreys, sea turtles (with a commercial fishery

in the Bay), and the extensive sea grass meadows? These are some of the abundance the Bay has yielded in former times.

Principal investigator for this project is Cynthia Howard; findings will be published in a GBNEP summary document.

Social Trends Affecting the Estuary

The Socioeconomics of Bay Utilization

Regulatory agencies have periodically used economic data to make estimates of the dollar values of various Bay uses. This information has never been brought together in a single study, and more importantly, the social trends underlying use of the Bay have never been adequately described. The most important aspect of this study, therefore, was to characterize social trends affecting the Bay system, as a tool to help determine possible effects of the CCMP on various populations associated with the Bay.

The elements of this study were: a demographic analysis utilizing the latest (1990) census data; identification of user groups and their dependence upon the Bay and one another; social trends for employment; and estimation of economic values of Bay uses based on previous studies. Specific elements of interest included: recreational fishing, boating, shipping, wastewater receiving, commercial fishing, land values, and oil and gas production. The "external costs" of using the bay were considered--those costs not paid directly by users, but which effect the resource.

This project resulted in a report compiled by Roger Durand, University of Houston--Clear Lake, to be published by the GBNEP. Results will strengthen a subsequent economic project entitled "Natural Resource Economics of Bay Use" to help determine the values of the Bay for management.

How Can We Pay for Stewardship?

Funding Source Inventory

Comprehensive management of Galveston Bay will require improved agency coordination, new enabling legislation, new programs, and higher efficiency for existing programs. This project will gather information needed to draft a Funding Strategy for these and other elements of CCMP implementation. Existing information on current local, state, and federal revenue sources will be drawn together to identify alternative ways to pay for improvements in management of the Bay.

The project is the first of four steps leading to a CCMP Funding Strategy. The remaining three are: (1) estimation of the costs for management alternatives proposed by the CCMP Task Forces; (2) establishment of a Financial Planning Committee under the Authority of the Policy Committee to rank funding sources and establish a strategy; and (3) drafting of the CCMP Financial Strategy itself for incorporation in the CCMP.

Public finance information and funding recommendations will be drawn together by Susan Hadden, University of Texas L.B.J. School of Public Affairs, and published in a report for use by the GBNEP in drafting the CCMP Funding Strategy.

The Grass Roots Effect: Public Participation

Observation and Coordination

Volunteer Bay-Watchers: A Citizen's Monitoring Plan

Water quality is a foremost concern in Galveston Bay because of its important relationships with public health, commercial fishing and wildlife populations, the conditions of habitat in the Bay, and the general quality of living on the coast. One of the fastest-growing grass roots environmental efforts in the country is citizen's water quality monitoring, pioneered in the Galveston Bay area by GBNEP in the Armand Bayou Coastal Preserve.

Economic reality, coupled with an increasing desire by government to be more responsive to citizens has encouraged this unique approach to environmental monitoring. Environmental agencies like the U.S. EPA and the Texas Water Commission realize that properly trained volunteers can be the "eyes" of the agency, reporting unusual occurrences and identifying trends before they become major problems to a water body. Citizens' interest is high because they can directly measure environmental quality, either to compare to, or to augment agency information. Because citizens live where the problems are, and have a stake in water quality in their community, their daily observations are increasingly valuable for long-term data gathering.

This project, begun in FY 1990, was developed by the Citizen's Monitoring Committee and is coordinated with the Texas Water Commission's "Texas Watch" program. The funds provide planning, training and limited equipment for environmental monitoring of the Armand Bayou watershed immediately adjacent to Galveston Bay. Certified volunteer monitors collect samples according to EPA and TWC protocols. This data is then utilized as a supplement to existing data collected by state and federal agencies. The program's success in its first two years has led to plans to expand the monitoring Bay-wide in FY 1993.

Response to Citizen Concerns

Pollution Reporting Hotline

Because citizens rarely know whom to contact when they witness pollution or activities that degrade the Galveston Bay watershed, the pollution reporting hotline was developed as a centralized reporting mechanism. Established in 1992, the hotline (1-800-3OUR BAY) is a demonstration project that enables the citizen to make one call and see results without being transferred to multiple persons and agencies.

Residents and visitors in the five counties surrounding Galveston Bay--Brazoria, Chambers, Harris, Galveston and Liberty Counties--may call the hotline to report any type of pollution they perceive as a problem. This includes land and water debris, oil and hazardous substance spills, fish and bird kills, bilge pumping, air emissions, storm drain dumping, improper waste disposal, and any other activities that may produce pollution. Trained volunteer operators take the calls

and make a detailed report. In emergency situations the proper authorities are dispatched immediately, otherwise, the hotline staff follows up with the appropriate agency and keeps track of each call's resolution. The citizen caller will receive written communication regarding the action taken.

Data on the pollution reports will be collected and assembled into an annual report to the Texas Legislature detailing problem areas, as well as gaps and overlaps in the environmental regulatory/enforcement structure. Information learned through the hotline will enhance recommended solutions to be incorporated into the CCMP. The Hotline is a project of the GBNEP Program Office in cooperation with the Citizen's Advisory Steering Committee.

Getting the Word Out **BayLine Newsletter**

BayLine is a quarterly newsletter, produced by the GBNEP staff with articles contributed by a variety of organizations and individuals in the Bay area. *BayLine* includes updates on the progress of CCMP development, summaries of published GBNEP reports, requests for public involvement with volunteer projects, and requests for information and input on specific issues that affect the estuary.

Each issue of *BayLine* usually utilizes a "theme" approach, highlighting a critical, and timely Bay topic. *BayLine* addresses all elements of the Priority Problems list and describes how the Management Conference is developing solutions.

Approximately 6,500 copies of *BayLine* are distributed to Management Conference and Public Forum members, business and industry in the Bay area, environmental groups, and elected officials representing jurisdictions around the Bay.

Spokespersons for the Bay **Speaker's Bureau and Portable Information Display**

The size and diversity of the five-county area around Galveston Bay makes communication with the community a challenge. The size of the geographic area makes it difficult for people to attend public meetings at any given location. Hundreds of newspapers and broadcast stations in the area create an atmosphere of "information overload" which busy citizens often tune out. For these reasons, plus a genuine desire for face-to-face communication with the public, the GBNEP staff and Management Conference volunteers have been "taking the show on the road."

Slide programs addressing the Priority Problems List and CCMP development are presented regularly by staff and trained volunteers. They speak at environmental and civic group meetings, professional and trades organizations, and educational institutions. Slides are supplemented by handouts about the program. Many new Public Forum members and newsletter subscribers are recruited at these

meetings.

In addition, a portable information display (approximately 8' wide by 8' tall) and supplementary materials were acquired for large audience education at trade shows, festivals and conferences. The display features current literature regarding the Bay and the GBNEP, and a short video production and eye-catching posters and displays to capture the interest of passers-by. The display is usually staffed by volunteers answering questions and distributing materials, but it can also be left unattended at a trade show or in a public place such as a library.

Both the Speaker's Bureau and Information Display are scheduled through the Program Office.

Documenting our Efforts

The GBNEP Publication Series

The GBNEP Publication Series produces Management Conference documents that serve a variety of functions to support drafting the CCMP. All of the GBNEP project reports are published in a "green cover" series and are made available to libraries and the public on request. These include the technical and scientific characterization studies of the Bay. Planning documents such as the *EPA/State Management Conference Agreement*, Membership Directories and Annual Work Plans are also part of the Series.

Future milestone publications include: an overall summary of technical findings, the *Galveston Bay Environmental Characterization Report*, a management evaluation entitled *Framework for Action: the Governance of Galveston Bay*, a public summary of our knowledge of the estuary to be used in the CCMP, *The State of the Bay*, and finally, the *Comprehensive Conservation and Management Plan* itself. A more complete description of these four milestone documents is provided in the introduction of this work plan.

Sharing the Message with the Public

Public Information Publications and Videotapes

Public information and education is vital to citizen participation in the improvement of Bay management, and a variety of printed materials and video productions are available for all ages. These include brochures, an informational poster about man's affects on the Bay, and (in the future) fact sheets summarizing the scientific and management topics for the general public.

The *Galveston Bay Recreational User's Handbook* is a guide to recreational activities around the Bay, including parks, fishing, boating and birding. It includes information that will help people use the Bay safely and responsibly, and promotes a general awareness of the recreational value of the estuary.

The *Galveston Bay Area Residents' Handbook* details many of the simple things Bay area residents can do to protect the Bay. It addresses the single greatest

cause of pollution in Galveston Bay: nonpoint source pollution. Nonpoint source pollution comes from diverse sources and in most cases results from the daily living activities of Bay Area residents. The handbook includes tips on lawn care, native plants, household hazardous wastes, boat and automobile care, and proper septic system maintenance.

Five videotape programs produced by GBNEP are available for loan to schools and organizations. They include: *Conflicting Uses of Galveston Bay*, *Oyster Harvesting and Conservation in Galveston Bay*, *Oil Spills—Marine Resources at Risk*, *Balancing Act—Christmas Bay and Armand Bayou Roles in Bay Conservation*, and the newest video, *Understanding the Galveston Bay Ecosystem*, a 30 minute program produced for high school marine science students, but suitable for many audiences. These videos encompass a variety of target audiences, and help the public to understand and to become involved with management of the Bay.

An Annual Celebration of Awareness **Bay Day**

Bay Day is a two-day event held every spring at Sylvan Beach Park, an historically significant bay-front recreation area in LaPorte. Bay Day is a festival in celebration of the Bay, as well as a spotlight on the significance of the estuary and need for wise use.

Bay Day is a cooperative venture of the GBNEP and the Galveston Bay Foundation, and is planned by an independent steering committee established for this purpose. The festival includes music, an arts and crafts market, children's games and activities, rides, a boat show, industrial, environmental, and heritage exhibits. There are boat races, helicopter rescue demonstrations, a fireboat demonstration, and fishing contests. Recreational interests are represented, as are business and industry in the Bay area. A major Saturday night concert on the main stage climaxes with a spectacular fireworks display over the water.

This family festival, intended to become an annual affair, is designed to increase public awareness of the Bay's value and diversity of uses. By focusing on the commercial as well as the ecological aspects of the Bay, Bay Day reinforces to the public the need for comprehensive management of the Bay. The event is volunteer intensive, and the GBNEP Public Forum is involved with staffing the event.

The GBNEP exhibit at Bay Day provides the opportunity to further increase the *BayLine* mailing list and the list of Public Forum volunteers who may want to participate in other activities.

Foundation for the Future **Youth Education and Outreach**

Educating the next generation is an important component of Bay conservation and preservation. The success of the CCMP over the next several decades depends directly on public understanding of, and concern for the Bay's resources.

The GBNEP works with existing formal and informal educational institutions (museums, nature centers, etc.) to develop programs about the Bay, using their staff and facilities. The education subcommittee of the CASC also plans educational projects to reach a wide range of students in school systems throughout the five county area around Galveston Bay. Past and present projects include:

- Bay Area Calendar Art Contest for school children
- Book covers for students to increase awareness of the Bay and nonpoint source pollution
- Teacher Training Program in environmental education, supported by the Galveston Bay Foundation, and facilitated by a University of Houston Professor
- Judging and support for local science fairs, with winners of the Regional Science Fair being honored at Bay Day
- Sponsorship of a local school district to develop a pilot project for Bay related environmental education
- Materials to accompany the Galveston Bay Ecosystem video

Future projects are also being considered. These include:

- Support for a Galveston Bay docent program, developed by the Galveston Bay Foundation Education Committee and a local science museum, to send trained docents—with educational materials—to local schools
- Essay contest for local middle school students.

In Touch with the Public at Large

Public Meetings

Public meetings provide formal interaction between program participants and the general public, and are a necessary part of the CCMP development process. Public meetings are scheduled when milestone publications are released, or when issues emerge that require extensive public input. In this way a continuing dialogue on important issues concerning the Galveston Bay System is maintained. Past public meeting topics include: Priority Problems in Galveston Bay; Oil and Hazardous Materials Spills; and Citizen Monitoring.